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N.W.

**Book 16
Climatic Data**

ADA 036424

Seafarer Site Survey Upper Michigan Region

for
**U.S. Navy
Naval Electronic Systems Command
Washington, D.C.**

by
**EDAW inc.
under contract to
GTE Sylvania
Communication Systems Division**

MAR 7 1971
GTE Sylvania

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20 ABSTRACT (Continue on reverse side if necessary and identify by block number) The Study Area has a temper- ate continental climate of the cool summer type. The hottest summer months are July and August with average approximate high and low temperatures of 75°F and 56.5°F, respectively. The coldest temperatures occur from December through March with mean high temperatures falling between 38.7°F and 22.5°F and lows between 20°F and 1.3°F. The winter climate in the study area is air mass controlled and hence is relatively unpredictable as to its severity from year to year.		

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20. Precipitation in the area is in the 30-32 inch range and average annual snowfalls range from 60 inches in the south to 120 inches in the north.

BOOK 16

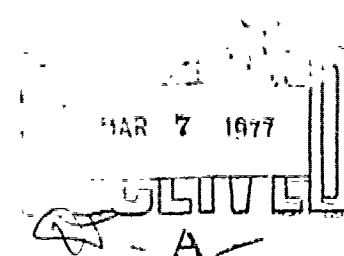
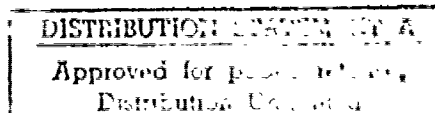
CLIMATIC DATA
of the
UPPER MICHIGAN REGION
PROJECT SEAFARER

for
U. S. Navy. Naval Electronic Systems Command

by
EDAW, Inc., 50 Green Street, San Francisco 94111

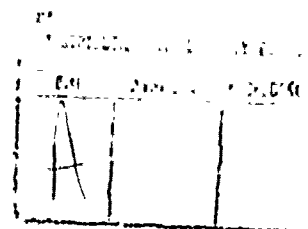
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April, 1976



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SUMMARY

The Study Area has a temperate continental climate of the cool summer type. Winter temperatures along the Lake Superior shore are from 6°F to 8°F warmer than the rest of the area, and in the summer 5°F to 6°F cooler. The hottest months of the summer are July and August with average high temperatures from 75.7° to 74.0° and low temperatures from 57.6°F to 57.5°F. The recorded high for the area is 102°F at Marquette, Michigan, in August 1947. The coldest temperatures occur in December, January, February, and March. During these months the mean high temperatures fall between 38.7°F and 22.5°F with the mean low temperatures ranging from 20°F to 1.3°F. The record low temperature of -46°F was recorded in February of 1951, at Kenton Weather Station in Houghton County.

The maximum depth of freezing in the Study Area averages 5' but is highly variable and can range from the surface only to 10' below the surface. Variation in the frost line is directly related to the amount of snow cover, therefore, the deeper the average snowfall the shallower the frost line. The variability in temperature and precipitation from year to year results in a corresponding variation in the depth of freezing from year to year.

Precipitation in the Study Area is from less than 30" to more than 32" and is evenly distributed throughout the year. Because of the even distribution of precipitation there is no definite wet or dry season. However, the summer rainfall is harder and of a shorter duration than other seasons, making the periods without rain longer and the summer seem dryer.

Snowfall occurs in the Study Area from September until May. The mean total snow depth at Marquette for each of these months is from 0" to 25" with the monthly maximum up to 52.6". Average annual snowfall for the site ranges from 120" in the northeastern part of the Study Area to 60" in the southern tip (see Climatic Data Map). In Marquette the greatest snowfall on record for any winter was 189.1" during the 1890-1891 season. Least snowfall for any season was 53.4" in 1940-1941.

In Marquette the average date of the first occurrence of freezing temperatures in autumn is October 20. The mean annual freeze-free period varies over the Study Area from more than 120 days along the Lake Superior shoreline to less than 60 days in the west central part.

In the Study Area, large annual temperature ranges are common due to extremely cold winters. These cold temperatures are caused by the southward advance of polar highs. These polar air masses are composed of extremely cold dry air which dominates the area until storms moving up from the south can displace them. The climate of the Study Area in the winter is an air mass controlled climate, and because of this is relatively unpredictable as to its severity from one year to the next.

EVOLUTION

The Upper Peninsula of Michigan has a temperate continental climate of the cool summer type. This is, especially in the summer, a land controlled climate which extends from 35° to about 50° latitude and east of the 100 meridian in the northern interior of the United States and southern Canada.

Large annual temperature ranges are common in this zone due to extremely cold winters. The severity of winters differs greatly from year to year because their temperatures are primarily air mass controlled and so fluctuate with the advance and retreat of polar highs.

There are three major factors which affect the winter climate of the Study Area: polar outbreak highs moving south out of Canada, deep cyclonic storms moving north out of Texas, and the relationship of the Study Area to the Great Lakes.

Polar outbreak highs are usually preceded by mild, warm fronts which bring rain or snow. After these fronts move through the area, winds shift from southwest to north and initiate a rapid drop in temperature as the polar high advances southward. This temperature drop is referred to as a cold wave and is typical of the winters of a continental climate. Cold waves end when deep cyclonic storms, originating in Texas, move northward bringing with them warmer temperatures, and rain or snow. The climate of this region is also modified somewhat by the Great Lakes. In the fall the lakes decrease the severity of the first cold winds from the north by warming them slightly. They also increase the moisture content of the north winds, thus increasing the snowfall in the area. This increased snowfall, however, is a localized effect and extends only about 20 miles inland.

The summer temperatures are less controlled by storms and exhibit a greater diurnal regularity. Two major elements control the summer weather: hot waves, and cold front thunderstorms. Hot waves are a response to long continued advection of tropical air masses by south winds. Eastward advancing cold front thunderstorms end the hot waves, shifting the winds from the south to the northwest and bringing cooler temperatures to the area.

DISTINCTIVE UNITS AND CHARACTERISTICS

Introduction

One climate type extends over the entire Study Area. However, there is some variation due to the localized effect of the Great Lakes.

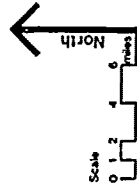
Illustrations of Climatic Data

The climatic data are delineated in three forms. The average annual snowfall is displayed on the Climatic Data Map; temperature and precipitation data are shown on small schematic maps (Figures 1, 2, and 3); and climatic data for the City of Marquette is plotted in graph form (Figures 4-8). (See Appendix A for exact readings used in making the graphs and additional climatic data.)

Seafarer Site Survey Upper Michigan Region

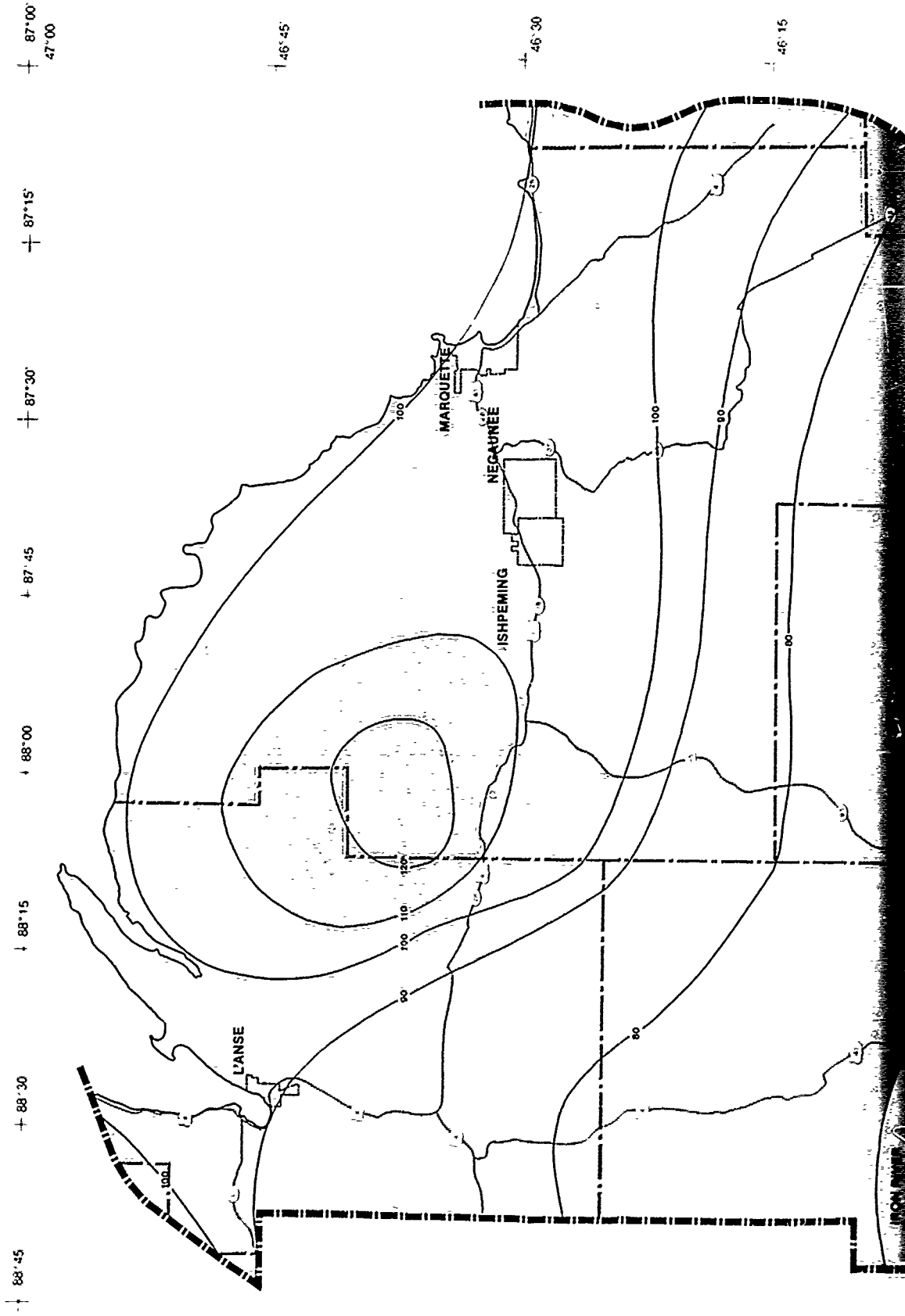
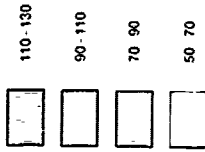
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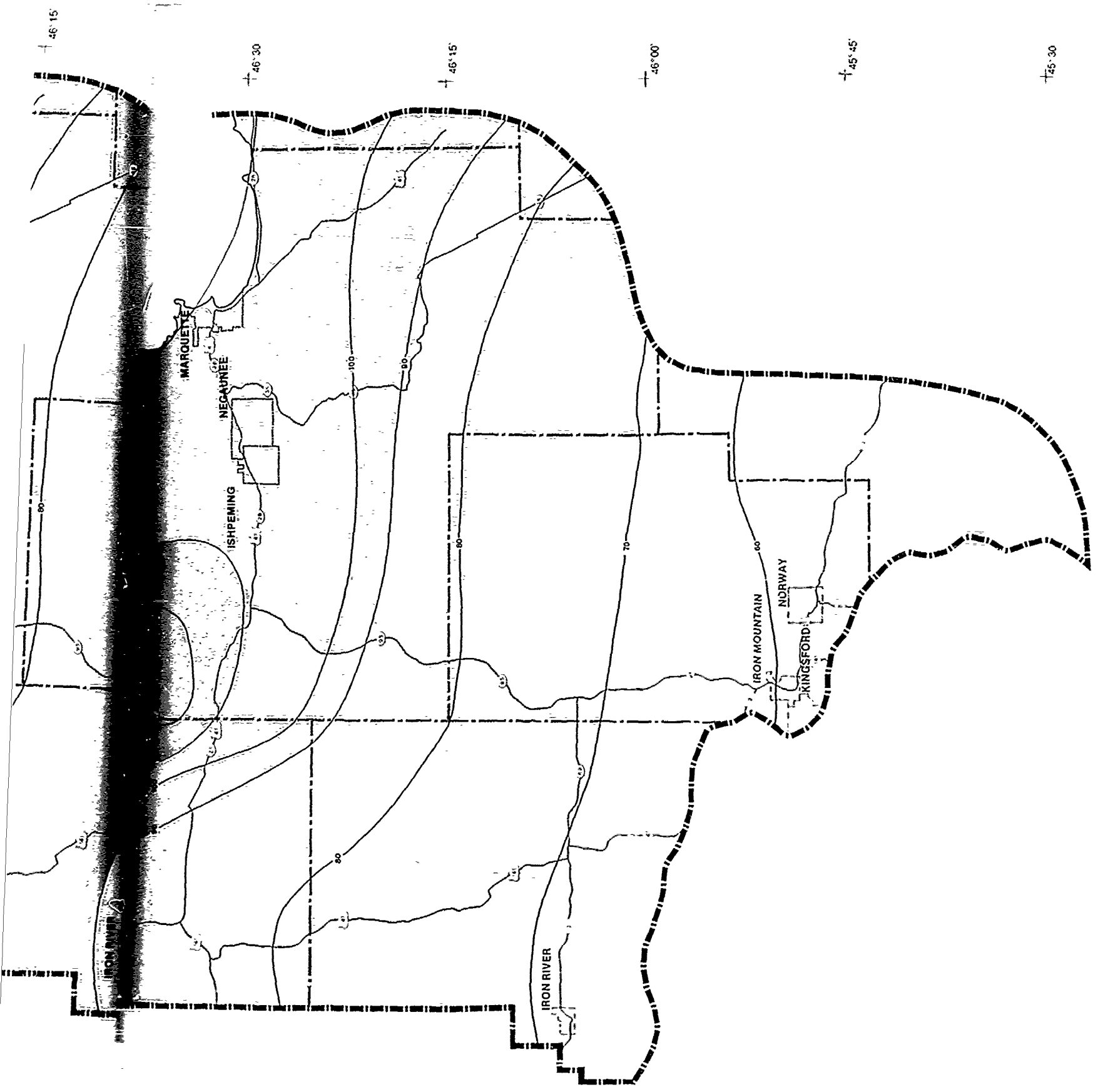
for
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Naval Electronic Systems Command
Washington, D.C.



CLIMATE

GENERALIZED SNOWFALL ZONES
(Average Annual Snowfall in Inches)





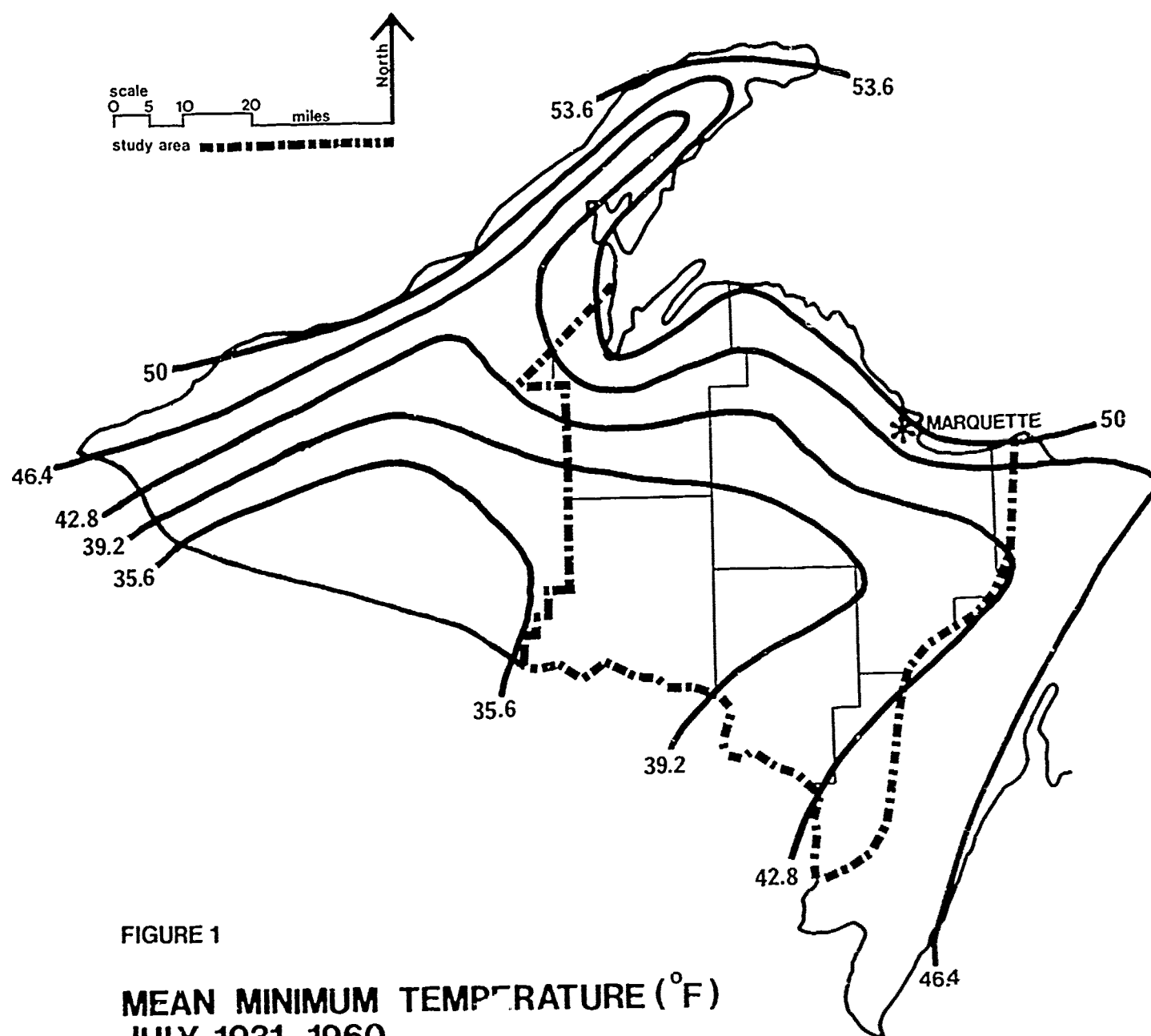


FIGURE 1

MEAN MINIMUM TEMPERATURE ($^{\circ}$ F)
JULY 1931-1960

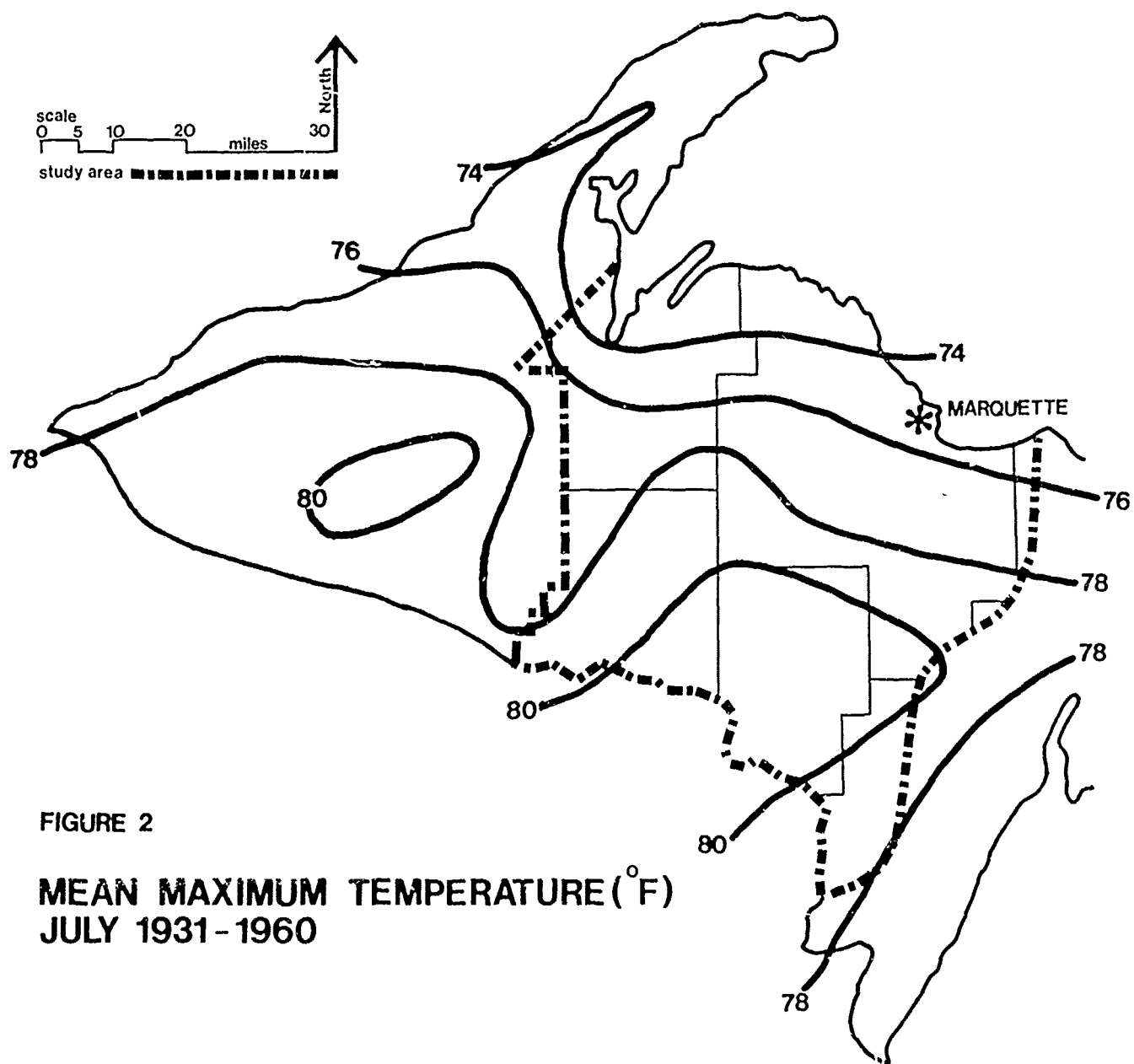


FIGURE 2

MEAN MAXIMUM TEMPERATURE ($^{\circ}$ F)
JULY 1931-1960

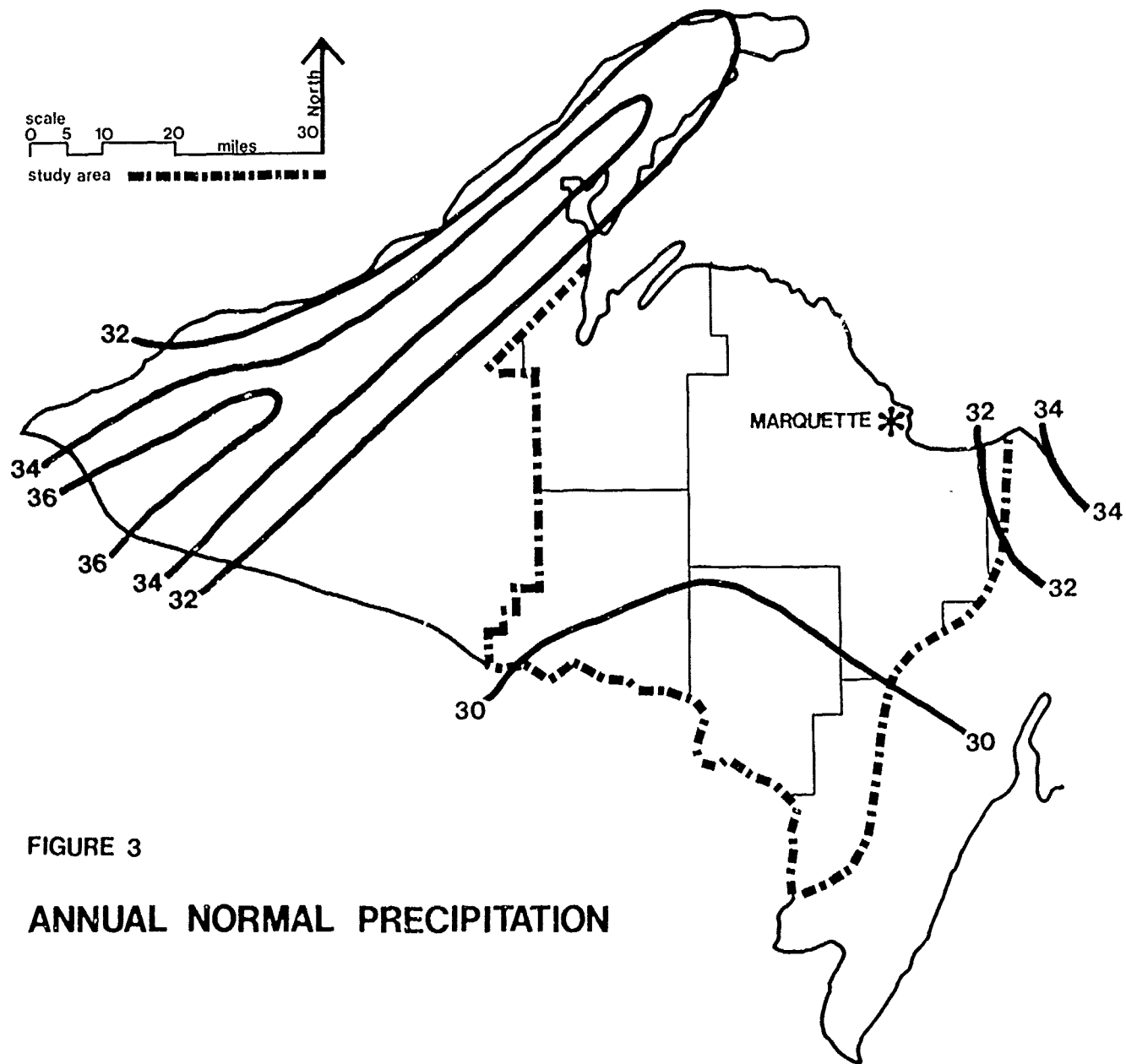


FIGURE 3

ANNUAL NORMAL PRECIPITATION

FIGURE 4

MAXIMUM & MINIMUM TEMPERATURE (MARQUETTE, MICHIGAN)

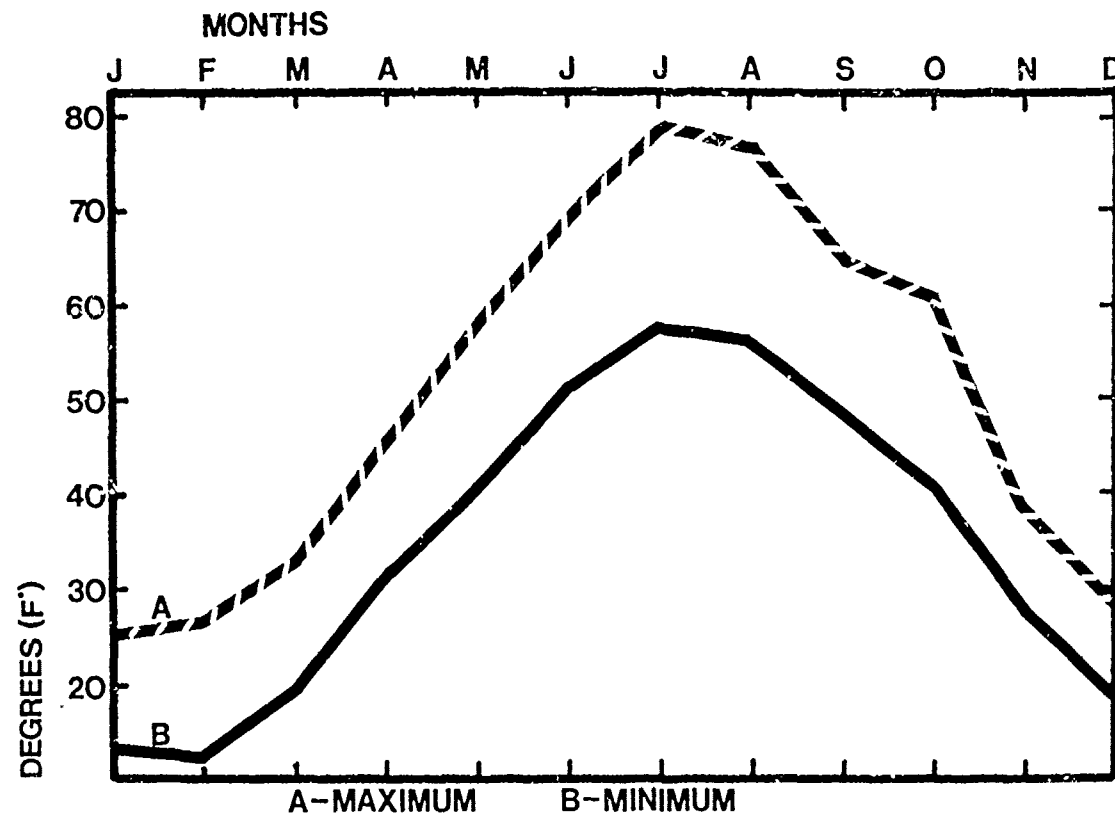


FIGURE 5

PERCENT HUMIDITY (MARQUETTE, MICHIGAN)

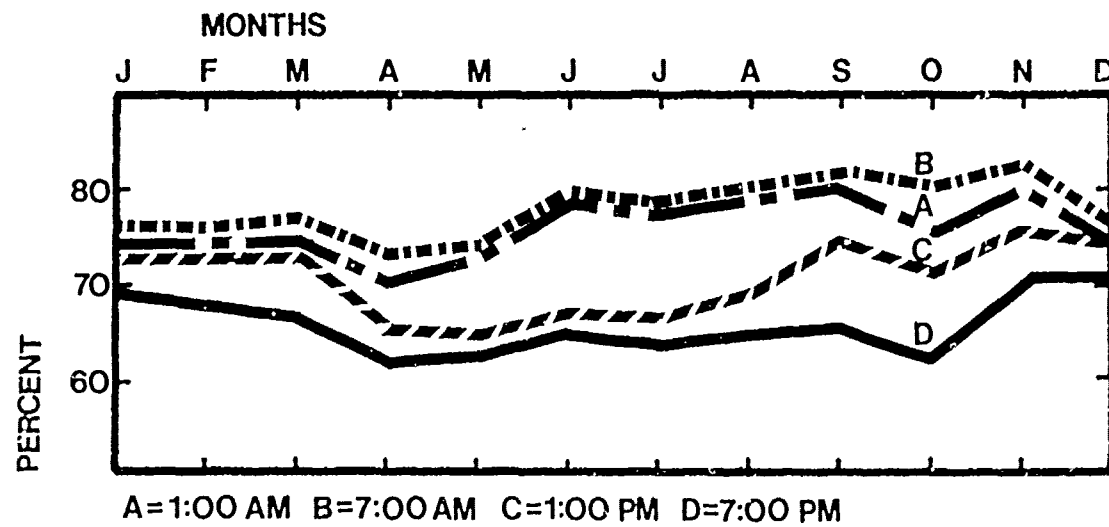


FIGURE 6

MAXIMUM & MEAN PRECIPITATION (MARQUETTE, MICHIGAN)

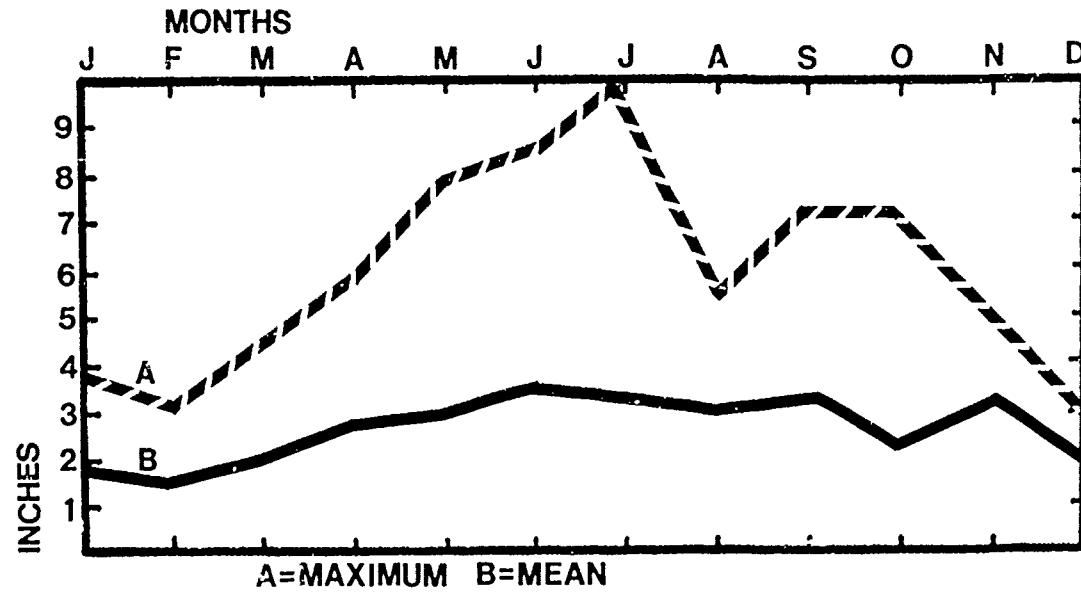


FIGURE 7

MAXIMUM & MEAN SNOW FALL (MARQUETTE, MICHIGAN)

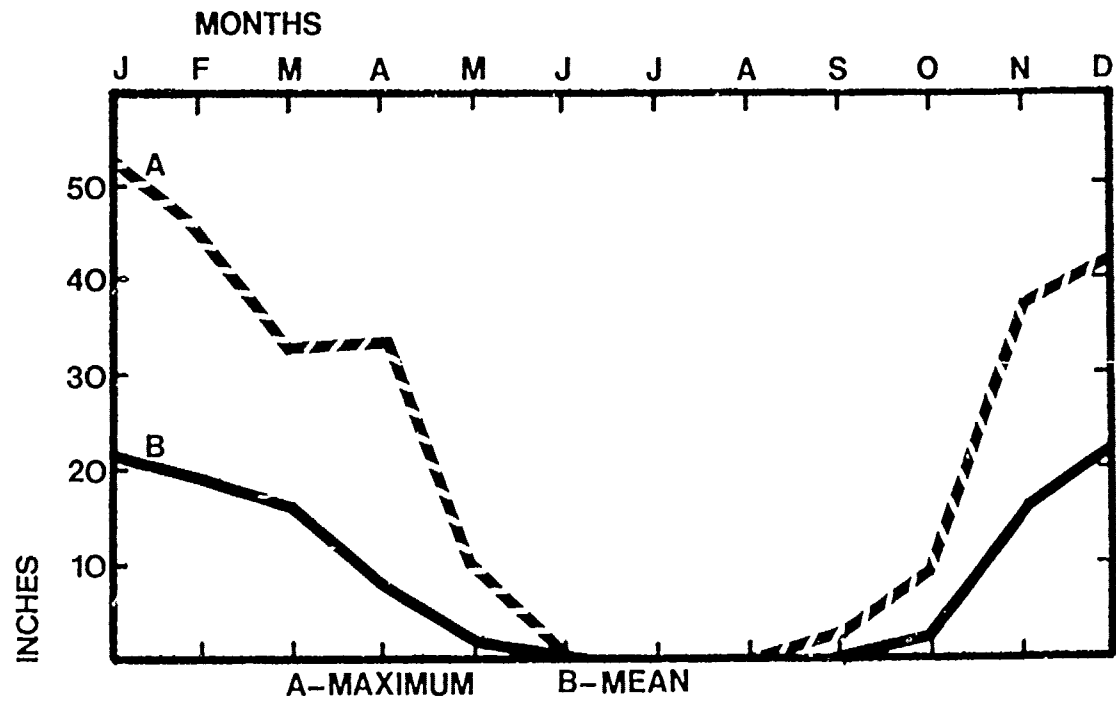
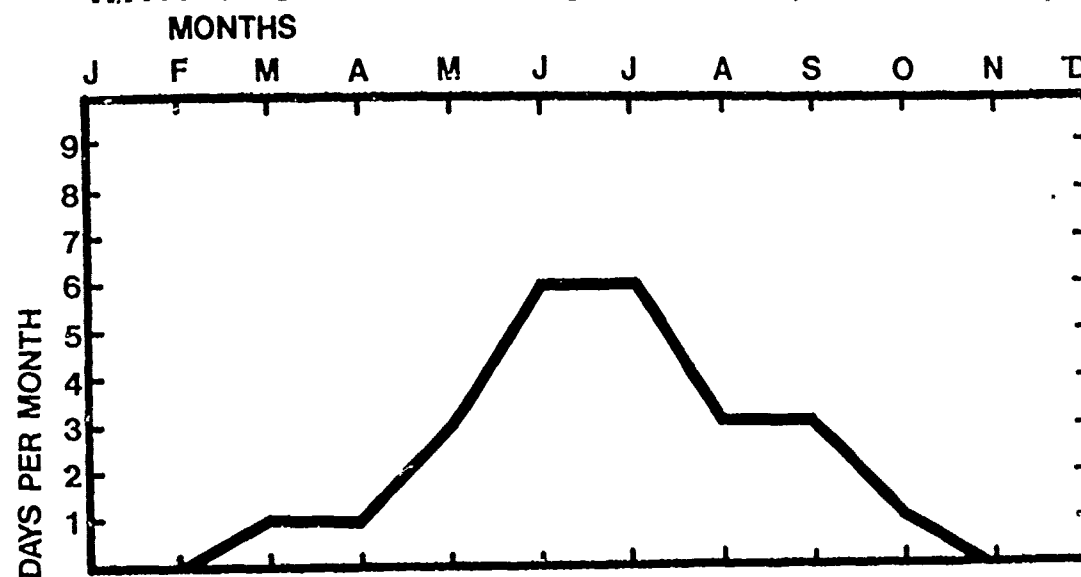


FIGURE 8

**MEAN NUMBER OF DAYS
WITH THUNDERSTORMS** (MARQUETTE, MICHIGAN)



RELATIONSHIP TO OTHER DATA

The climate has a strong relationship to all of the other natural and cultural processes. It controls the life cycles of animals and plants, and the agricultural practices of man. It affects the character of the stream flow and the amount of ground water available.

The temperature and humidity of a climate are directly related to the effectiveness of mechanical cooling systems. Extreme and rapid changes in weather affect the curing time of concrete, the productivity and safety of workers, and the transportation of goods. The depth of freezing has a strong effect on all forms of construction.

VALIDITY

Form of Data Presentation

Climatic data have been recorded in three forms: a large-scale mylar map (1" = 2 miles) reduced for this report; small-scale schematic maps (Figures 1-3), and graphs of data from a typical weather station in the Study Area (Figures 4-8).

Snow depth data were plotted at the large scale, 1" = 2 miles. This was done because these data are a primary guide to the depth of freezing in the area. Therefore, in order that it may be used in the analysis process it was plotted at the same scale as the other data groups.

Mean maximum and minimum temperature and normal annual precipitation data are plotted on small scale schematic maps. This type of plotting allows one to understand the variation in climate over the site and then when reading the graphs for the Marquette weather station (represented by * on the small maps), the relationship of that data to the rest of the Study Area can be more clearly understood. The other relevant climatic data were plotted in graph form to emphasize their seasonal fluctuation.

Selection of Data Collection Points

The weather station at Marquette was the only one within the Study Area that had reasonably complete data. These data were therefore selected as the source for figures 4-8.

Data Sources

The source for the data used in plotting all graphs was the U. S. Department of Commerce National Oceanic and Atmospheric Administration, Environmental Data Service, Local Climatological Data of Marquette Michigan. Temperature and precipitation data were recorded for a 29 year period ending in 1960; snowfall data were recorded for 34 years ending in 1971; and humidity and thunderstorm data were recorded for 27 years ending in 1971.

The small-scale temperature and precipitation maps and large-scale snowfall map were all plotted from data recorded from 1931 until 1960 by the Michigan Weather Service.

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APPENDIX

CLIMATIC DATA

[illegible]

Source: U. S. Department of Commerce National Oceanic and Atmospheric Administration
Environmental Data Service Publication. Local Climatological Data of
Marquette, Michigan.

Dimensional Units:
 Temperature - Degrees Fahrenheit
 Precipitation - Inches
 Snowfall - Inches
 Wind- Miles per Hour

NORMALS, MEANS & EXTREMES

[illegible]

2000-2001

[illegible]

* Through 1904. The census did not operate in South Africa, the only
 11 countries, data may be incomplete.
 2 Through 1922 3 Through 1904.

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Source: U. S. Department of Commerce National Oceanic and Atmospheric Administration Environmental Data Service Publication. Local Climatological Data of Marquette, Michigan.

Dimensional Units:

Temperature - Degrees Fahrenheit

Precipitation - Inches

Snowfall - Inches

Wind - Miles per Hour

SNOWFALL (inches)

[illegible]

PRECIPITATION (inches)

[illegible]

Source: U. S. Department of Commerce National Oceanic and Atmospheric Administration Environmental Data Service Publication. Local Climatological Data of Marquette, Michigan.

TOTAL DEGREE DAYS

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
1922-23	75	32	175	61	1028	1332	2232	1360	1339	814	421	11	8317
1923-24	72	15	152	61	1054	1466	2272	1313	1311	844	285	275	9315
1924-25	101	117	318	64	1359	1668	2213	1311	1311	835	285	275	9619
1925-26	36	84	306	316	1232	1264	1314	1066	1165	518	457	235	7255
1926-27	46	101	325	325	1200	1314	1365	1165	1165	617	517	235	7791
1927-28	45	115	405	355	1355	1355	1355	1165	1165	708	517	235	8693
1928-29	45	115	405	355	1355	1355	1355	1165	1165	708	517	235	8693
1929-30	66	45	445	410	1216	1275	1355	1165	1165	708	517	235	9012
1930-31	45	215	605	450	1516	1516	1215	1315	1315	474	315	75	7597
1931-32	31	101	305	311	975	1275	1309	1215	1215	502	315	265	6203
1932-33	45	115	325	325	1200	1314	1365	1165	1165	617	517	235	7791
1933-34	45	115	325	325	1200	1314	1365	1165	1165	617	517	235	7791
1934-35	25	25	25	35	915	1215	1305	1215	1215	574	365	155	5911
1935-36	45	115	325	325	1200	1314	1365	1165	1165	617	517	235	7791
1936-37	31	31	281	305	945	1350	1405	1350	1350	695	325	215	6378
1937-38	31	31	281	305	945	1350	1405	1350	1350	695	325	215	6378
1938-39	104	71	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1939-40	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1940-41	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1941-42	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1942-43	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1943-44	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1944-45	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1945-46	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1946-47	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1947-48	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1948-49	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1949-50	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1950-51	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1951-52	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1952-53	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1953-54	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1954-55	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1955-56	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1956-57	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1957-58	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1958-59	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1959-60	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1960-61	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1961-62	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1962-63	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1963-64	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1964-65	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1965-66	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1966-67	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1967-68	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1968-69	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1969-70	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1970-71	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1971-72	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044

TOTAL DEGREE DAYS

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
1922-23	75	32	175	61	1028	1332	2232	1360	1339	814	421	11	8317
1923-24	72	15	152	61	1054	1466	2272	1313	1311	844	285	275	9315
1924-25	101	117	318	64	1359	1668	2213	1311	1311	835	285	275	9619
1925-26	36	84	306	316	1232	1264	1314	1066	1165	518	457	235	7255
1926-27	46	101	325	325	1200	1314	1365	1165	1165	617	517	235	7791
1927-28	45	115	405	355	1355	1355	1355	1165	1165	708	517	235	8693
1928-29	45	115	405	355	1355	1355	1355	1165	1165	708	517	235	8693
1929-30	66	45	445	410	1216	1275	1355	1165	1165	708	517	235	9012
1930-31	45	215	605	450	1516	1516	1215	1315	1315	474	315	75	7597
1931-32	31	101	305	311	975	1275	1309	1215	1215	502	315	265	6203
1932-33	45	115	325	325	1200	1314	1365	1165	1165	617	517	235	7791
1933-34	45	115	325	325	1200	1314	1365	1165	1165	617	517	235	7791
1934-35	25	25	25	35	915	1215	1305	1215	1215	574	365	155	5911
1935-36	45	115	325	325	1200	1314	1365	1165	1165	617	517	235	7791
1936-37	31	31	281	305	945	1350	1405	1350	1350	695	325	215	6378
1937-38	31	31	281	305	945	1350	1405	1350	1350	695	325	215	6378
1938-39	104	71	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1939-40	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1940-41	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1941-42	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1942-43	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1943-44	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1944-45	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1945-46	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1946-47	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1947-48	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1948-49	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1949-50	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1950-51	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1951-52	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1952-53	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1953-54	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1954-55	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1955-56	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1956-57	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1957-58	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1958-59	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1959-60	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1960-61	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1961-62	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1962-63	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1963-64	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1964-65	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1965-66	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1966-67	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1967-68	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1968-69	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1969-70	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1970-71	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044
1971-72	31	165	276	276	1045	1325	1355	1355	1355	607	335	225	7044

Source: U. S. Department of Commerce National Oceanic and Atmospheric Administration Environmental Data Service Publication. Local Climatological Data of Marquette, Michigan.